Charge and Light Anticorrelation for electrons and muons in the FD

Updates

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Overview

Where we were:

- light and charge anticorrelation using monoenergetic single particles genereted isotropically in the FD (see https://indico.fnal.gov/event/46502/contributions/206593/attachments/139362/174892/brunetti_anticorr_fd.pdf)

Today's slides:

We moved to LarSoft version v09_16_00

We study the light-charge anticorrelation using new samples of:

- monoenergetic (1 GeV) single electrons,
- monoenergetic (1 GeV) single muons.

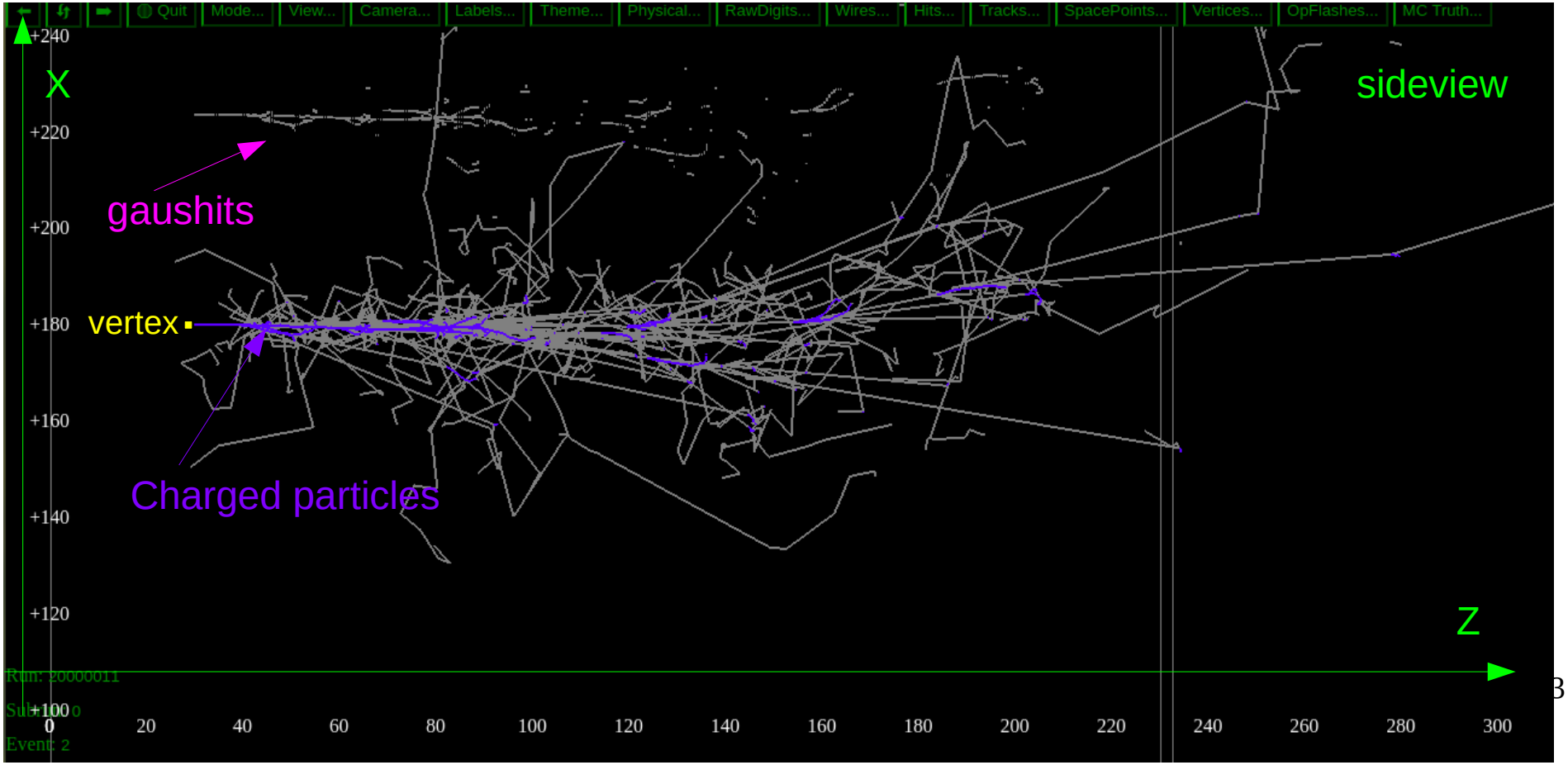
These new samples were generated in the refactored geometry: dune10kt_1x2x6_v4_refactored_geo, in a fixed vertex position and a fixed direction (forward going in z) to make sure we have contained events.

1 GeV Electrons

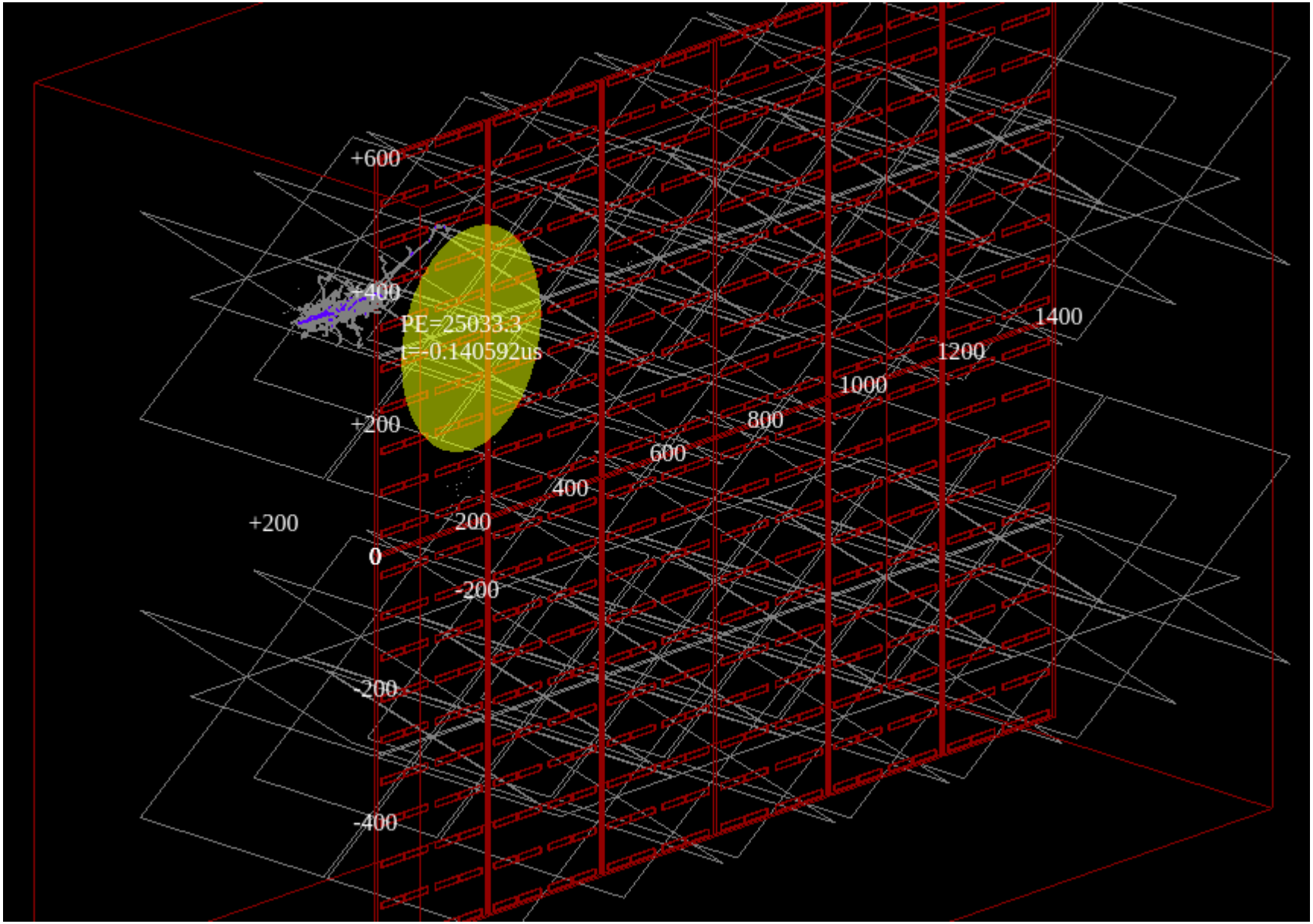
- 500 **monoenergetic electrons**, ALL simulated with

  Energy=1 GeV
  Vertex in: x=+180, y=+300, z=+30
  Forward-going θ0XZ=0, θ0YZ=0, σθ=0

- EM shower is contained in the detector, 84% of the events have total energy deposited >998 MeV
- Tipically an event looks like this:

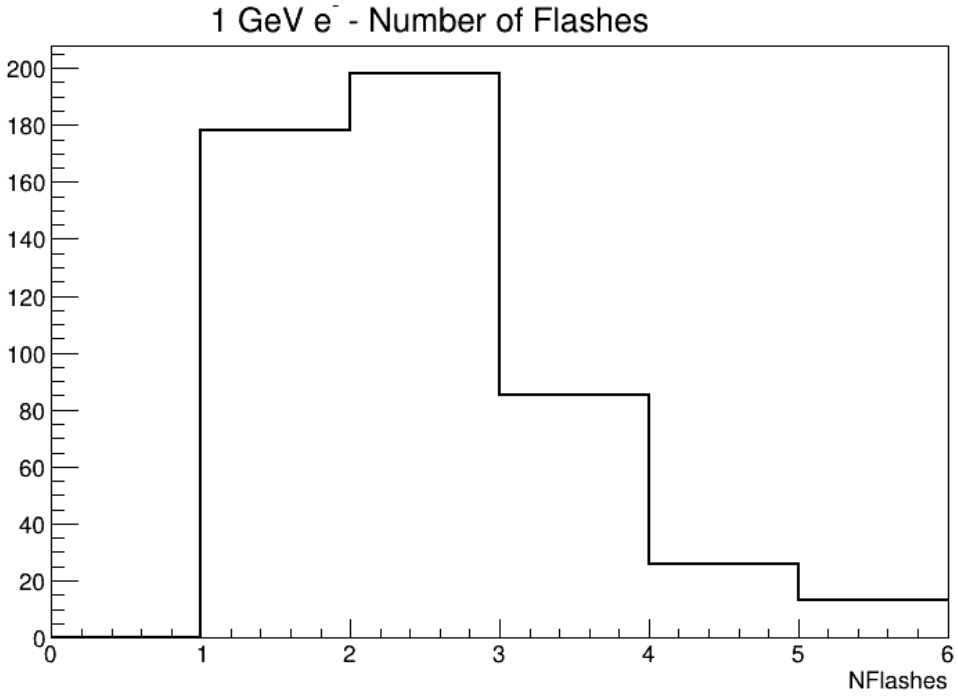


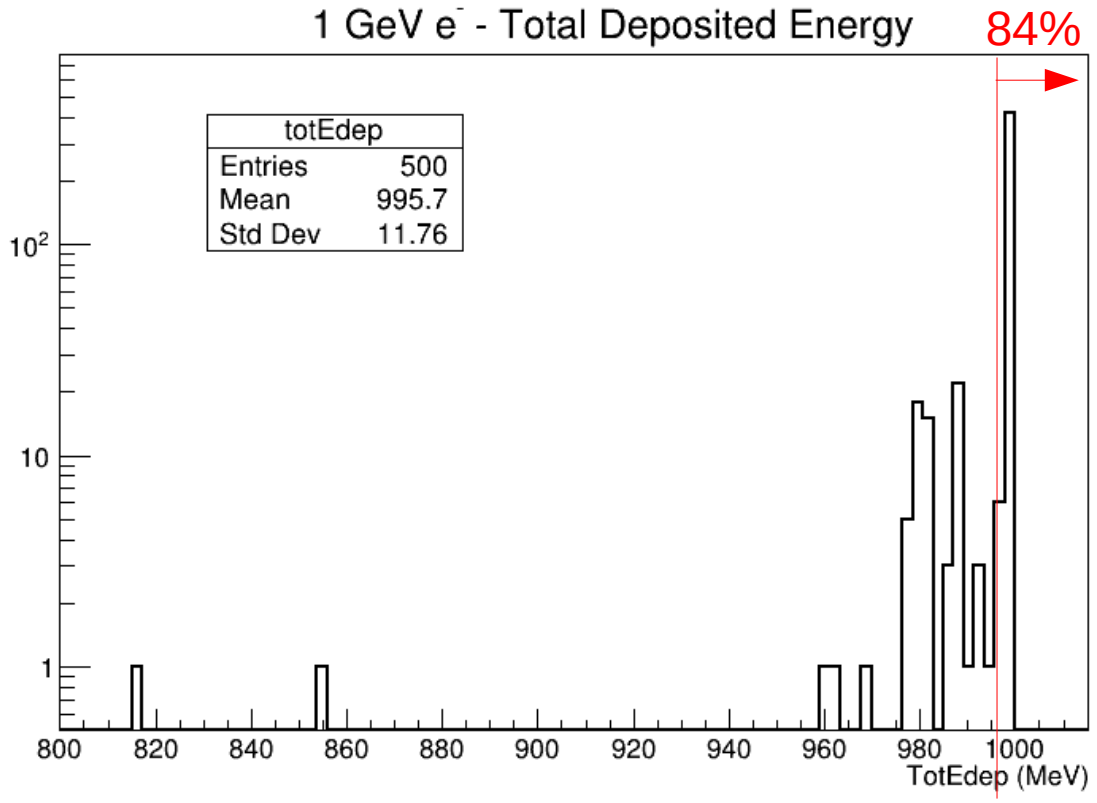
1 GeV Electrons



1 GeV Electrons

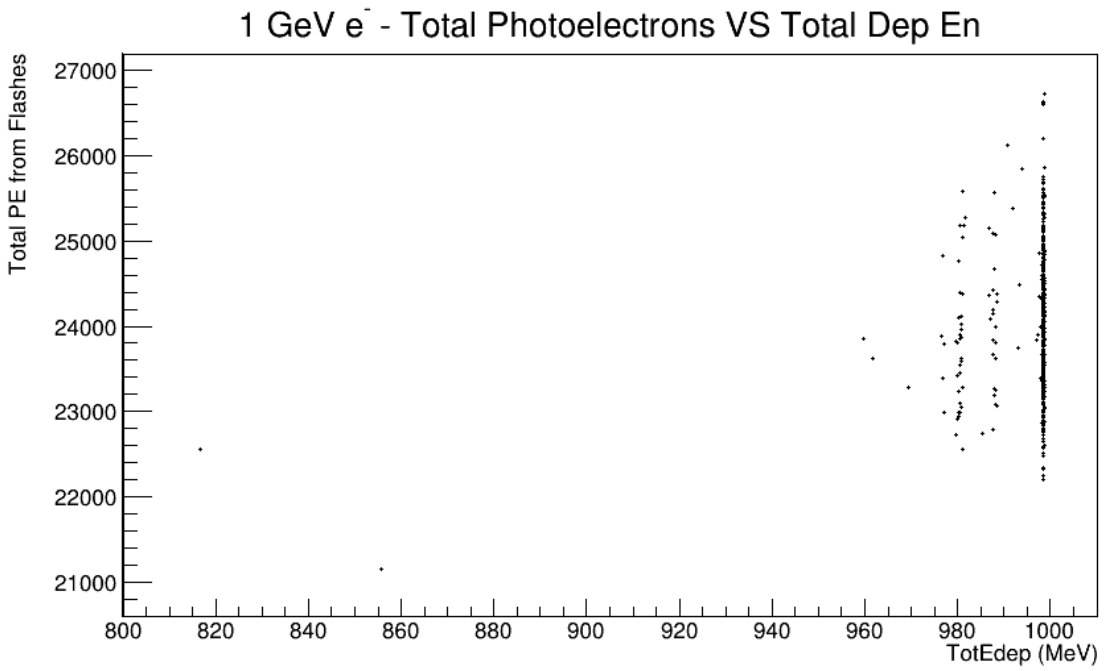
- **LIGHT**: Get total number of photoelectrons from reconstructed Flashes, using all the flashes in the event
- **CHARGE**: Get the charge from reco gaushits (sum of hit Integral under the calibrated signal waveform of the hit, in tick x ADC units)
- **DEPOSITED ENERGY**: IonAndScint Algo (Correlated)



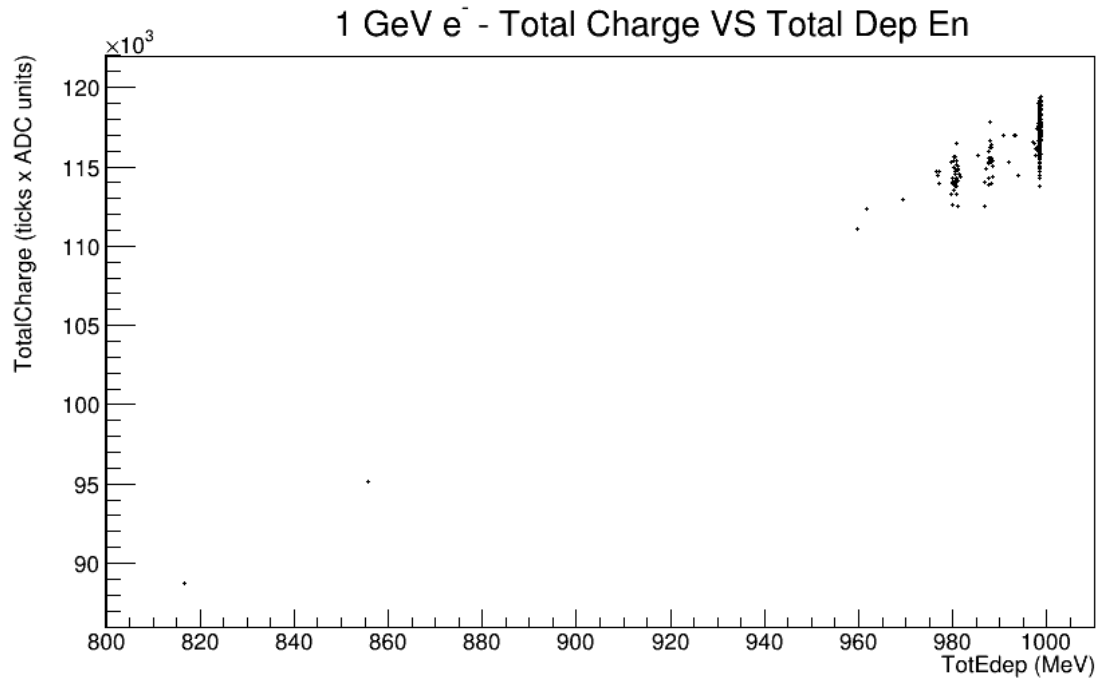


1 GeV Electrons

- **LIGHT**:
  Photoelectrons vs Deposited Energy



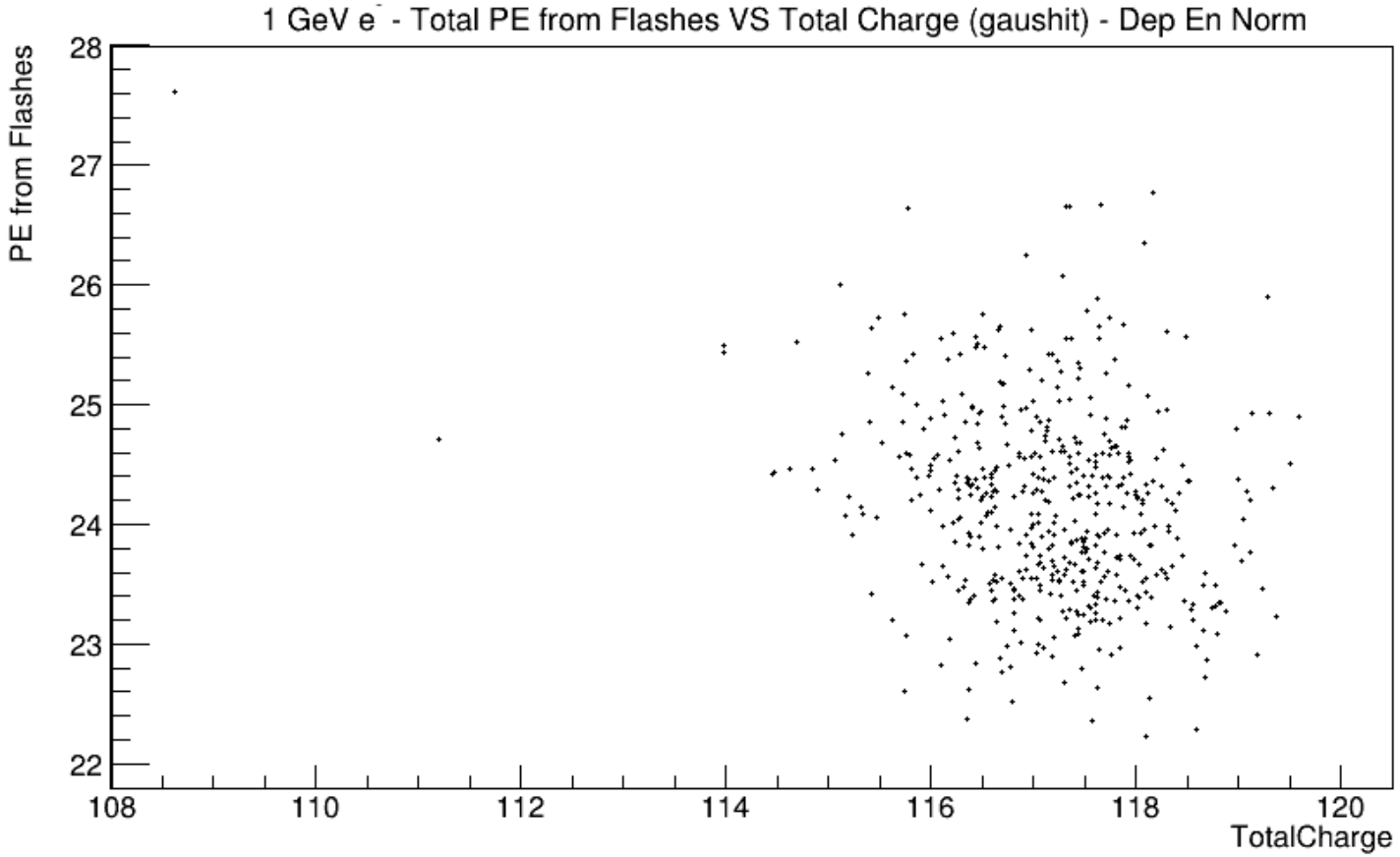
- **CHARGE**:
  Total Charge vs Deposited Energy



*Quantization of deposited energy as seen before.
It's visible also without using reco info from flashes and gaushits, see slide 8.

1 GeV Electrons

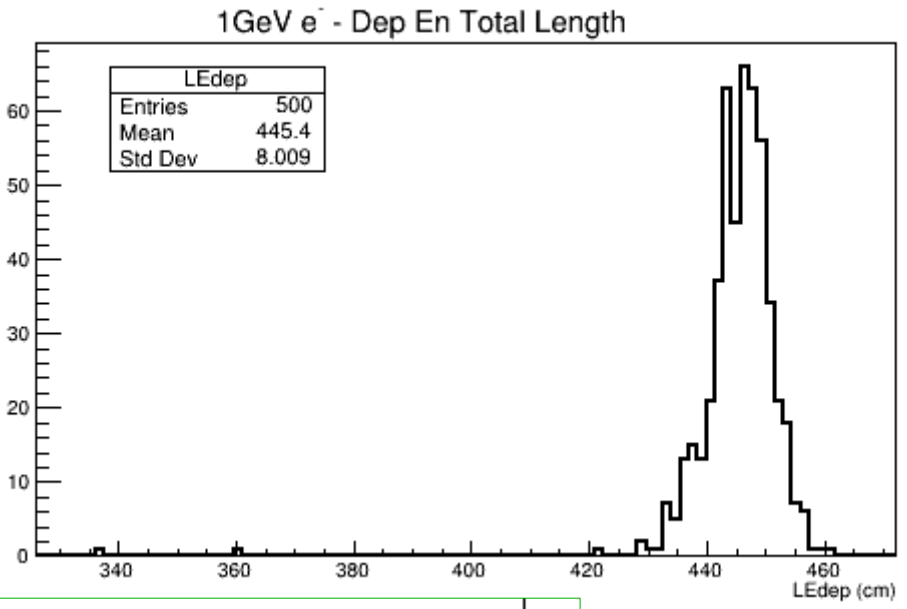
- **LIGHT VS CHARGE per Deposited Energy**



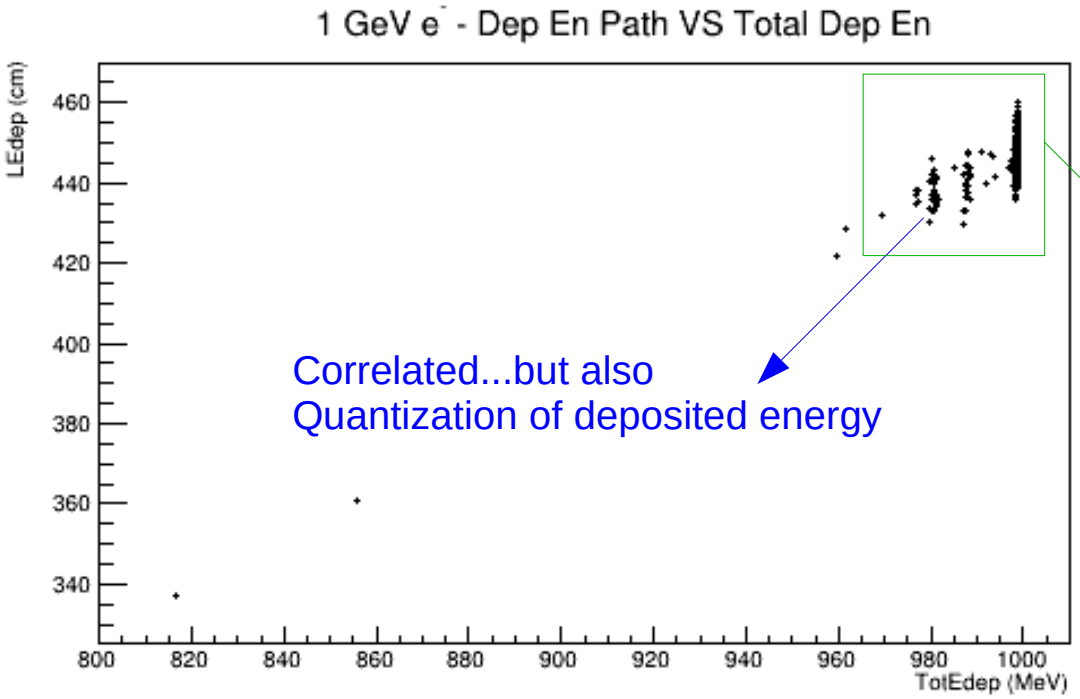
Anticorrelation is not really visible… check IonAndScint depositions

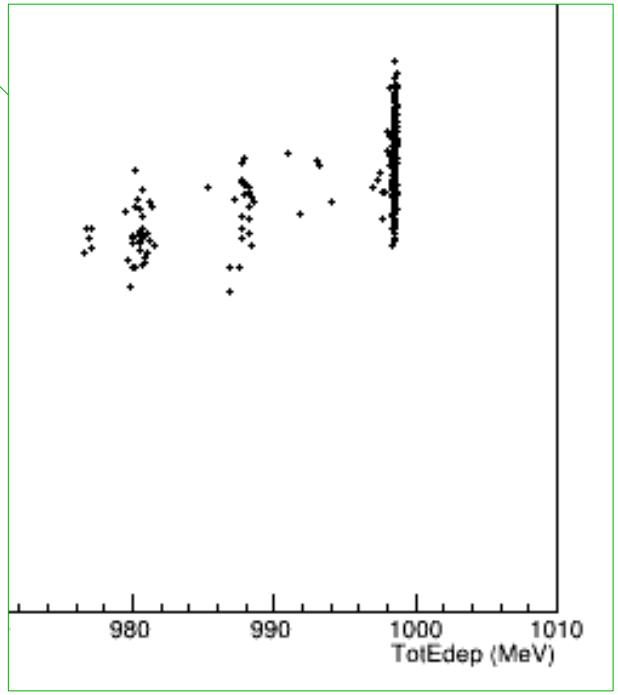
1 GeV Electrons

- **IonAndScint,** checking single depositions: Deposited energy, step length, Ionization electrons and Scintillation Gammas emitted
- Sum of deposition steps for 1 GeV electrons → 445.4 cm



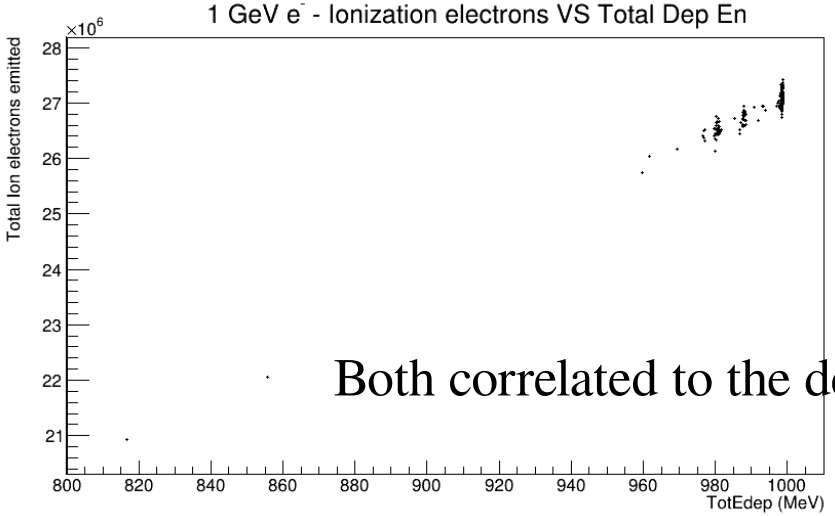
- Total Deposition Path vs Total Deposited Energy :

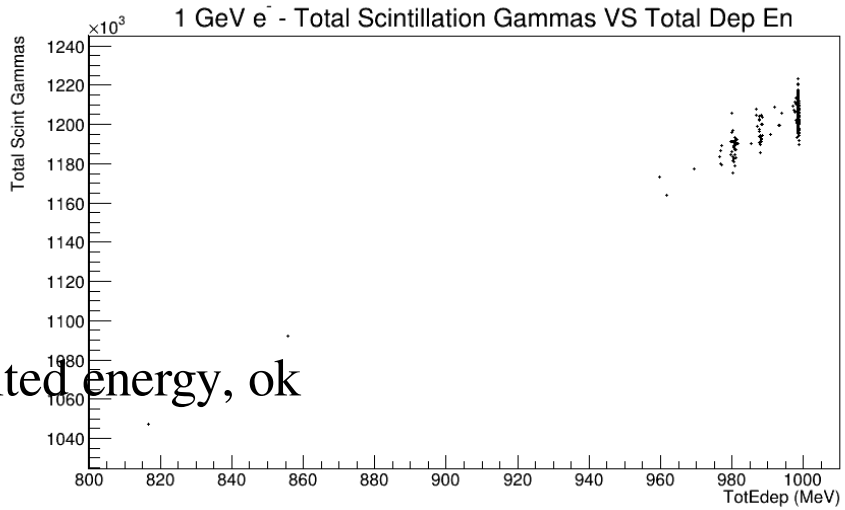




1 GeV Electrons

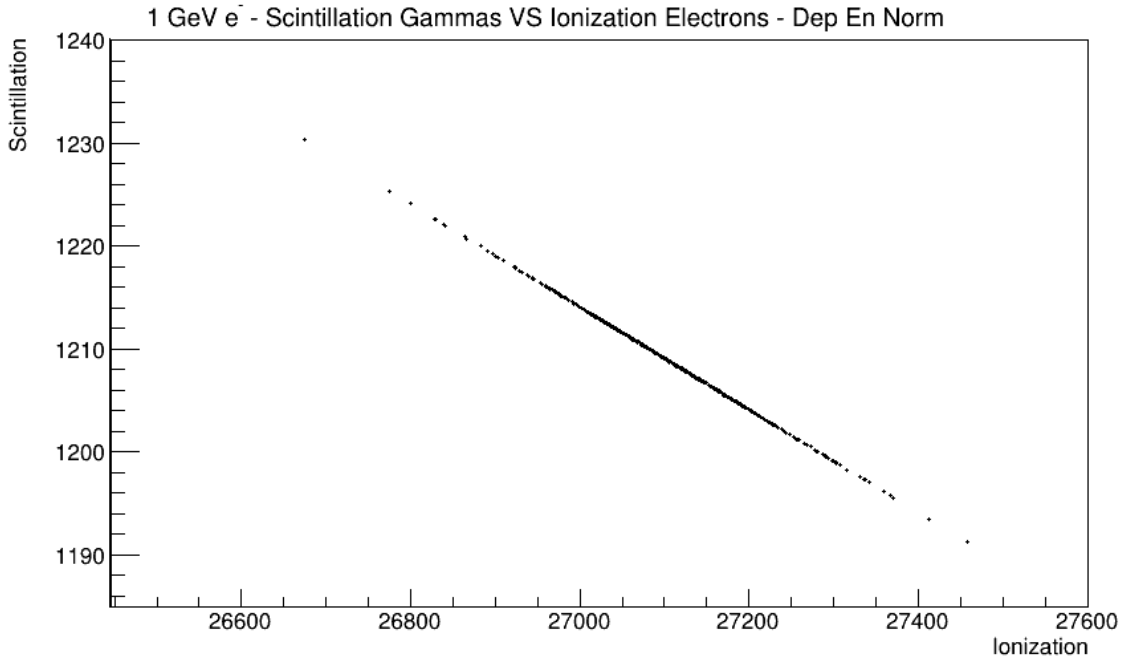
- **IonAndScint**:
  Ionization electrons and Scintillation gammas emitted vs Deposited Energy





Both correlated to the deposited energy, ok

Scintillation Gammas vs Ionization Electron - Dep En Norm



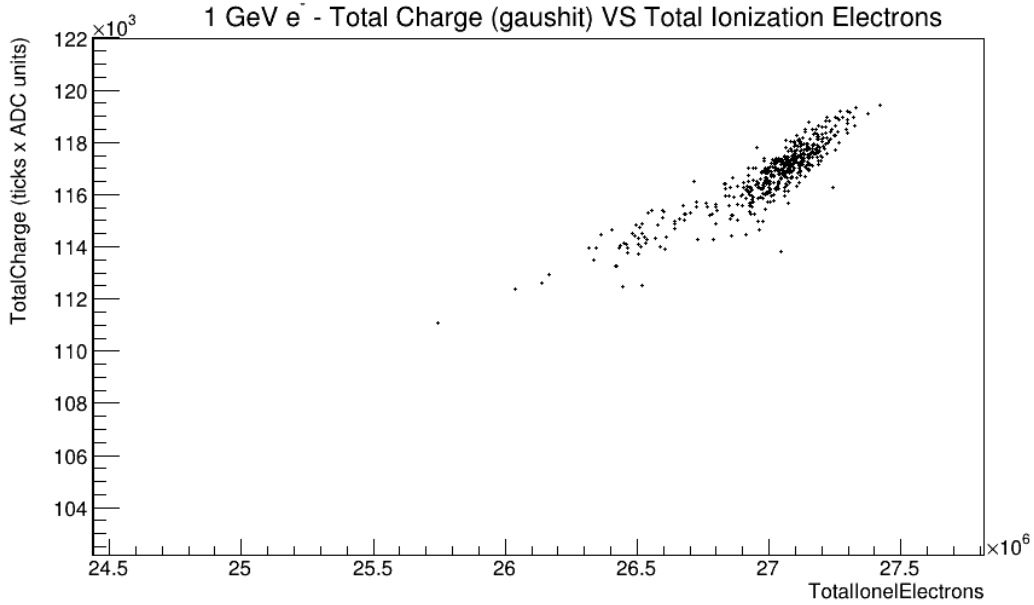
Clear Anticorrelation ok!

…then check reconstructed info wrt IonAndScint

1 GeV Electrons

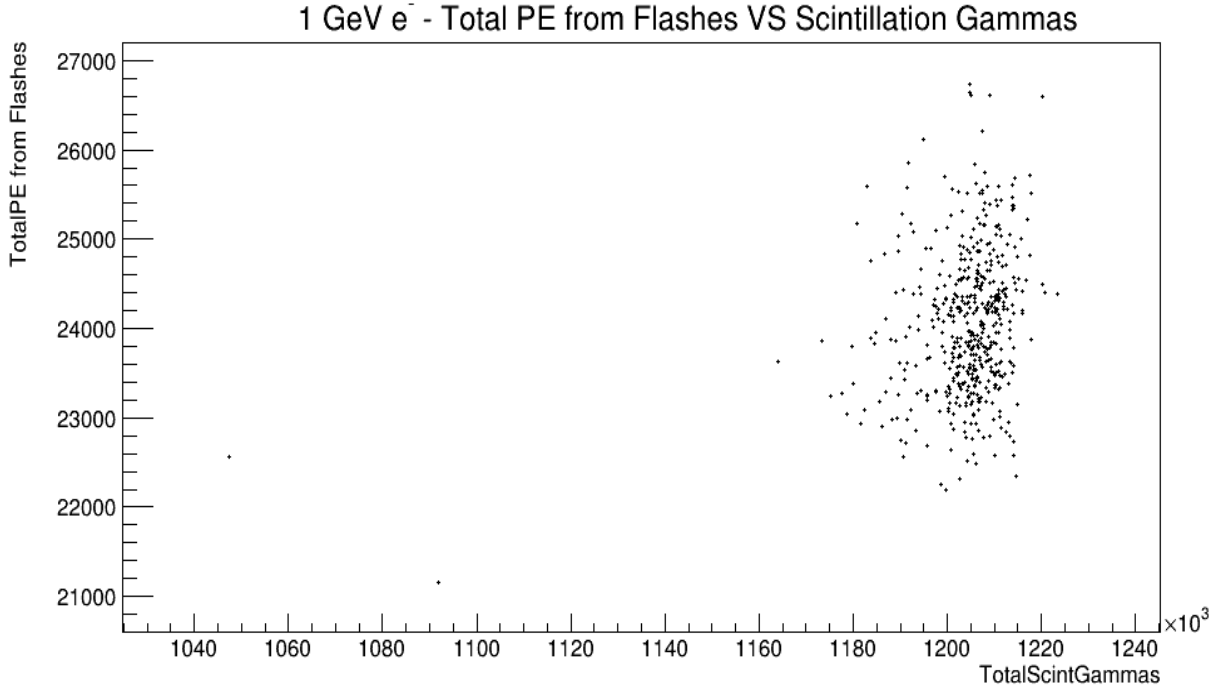
- Total Charge VS Ionization electrons

Good correlation



- Total PE from Flashes VS Scint. Gammas

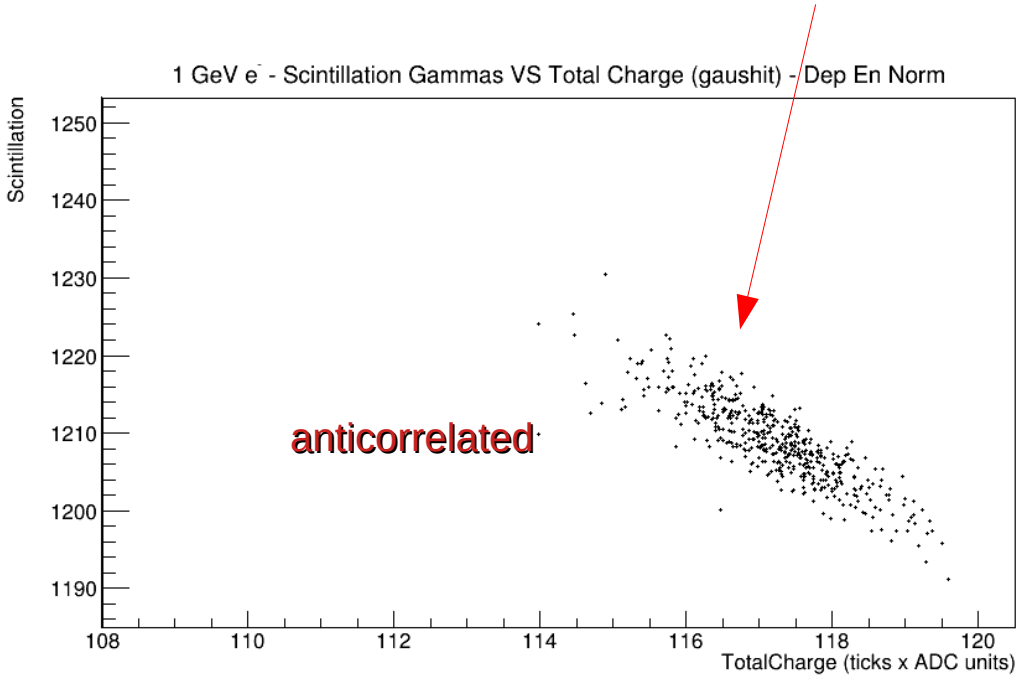
Correlation?

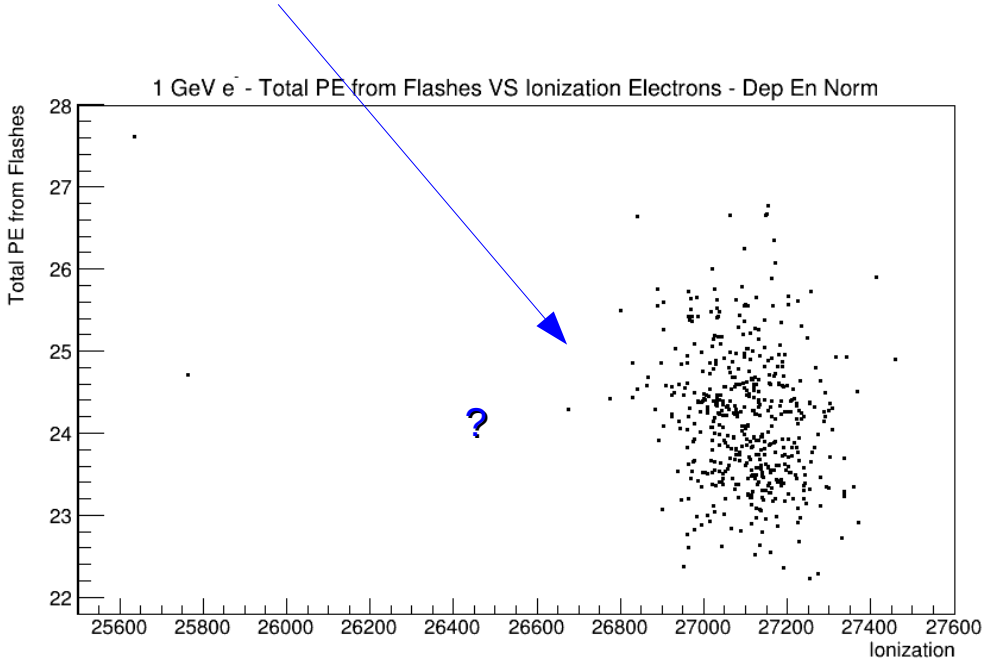


1 GeV Electrons

Looks like the anticorrelation is not clear when usign Flashes and reco hits because the PE of the reconstructed flashes are not clearly correlated with the emitted gammas

In fact,
if we check: Scintillation gammas vs reco charge OR Flashes light vs ionization electrons:



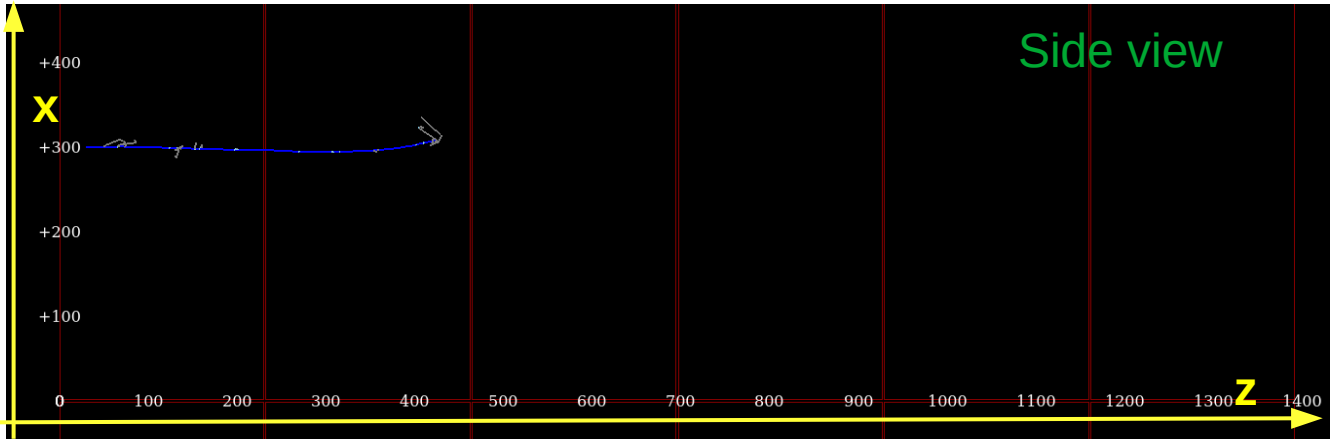


1 GeV Muons

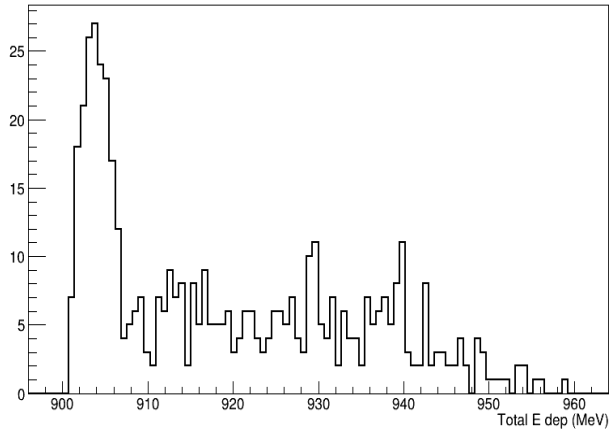
- 500 **monoenergetic muons**, ALL simulated with

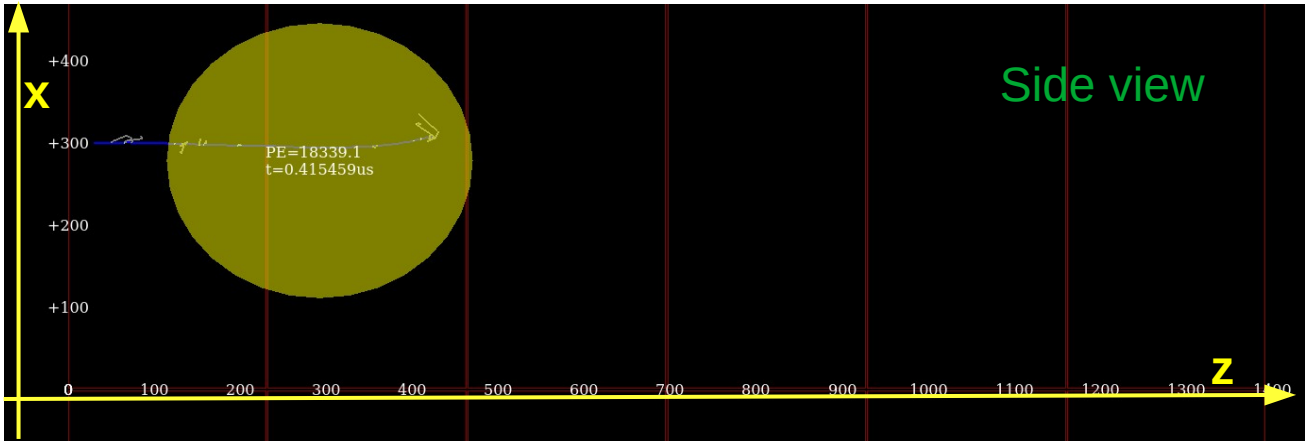
  Energy=1 GeV
  Vertex in: x=+180, y=+300, z=+30
  Forward-going θ0XZ=0, θ0YZ=0, σθ=0

- Tipically an event looks like this and it extends over 2 TPCs in beam direction.

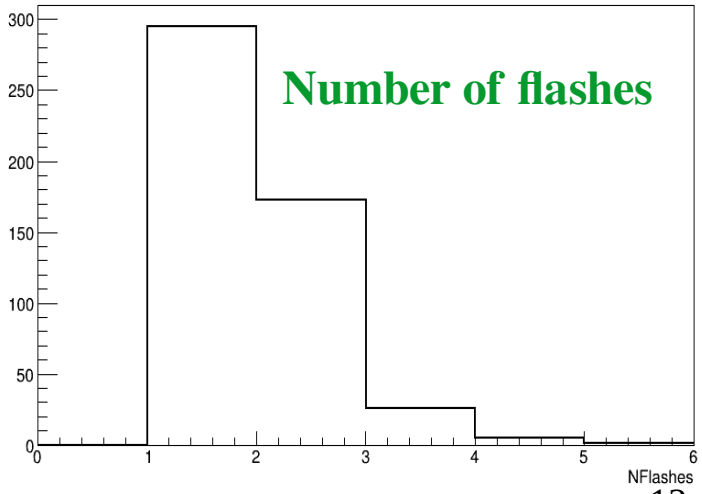


Total deposited energy



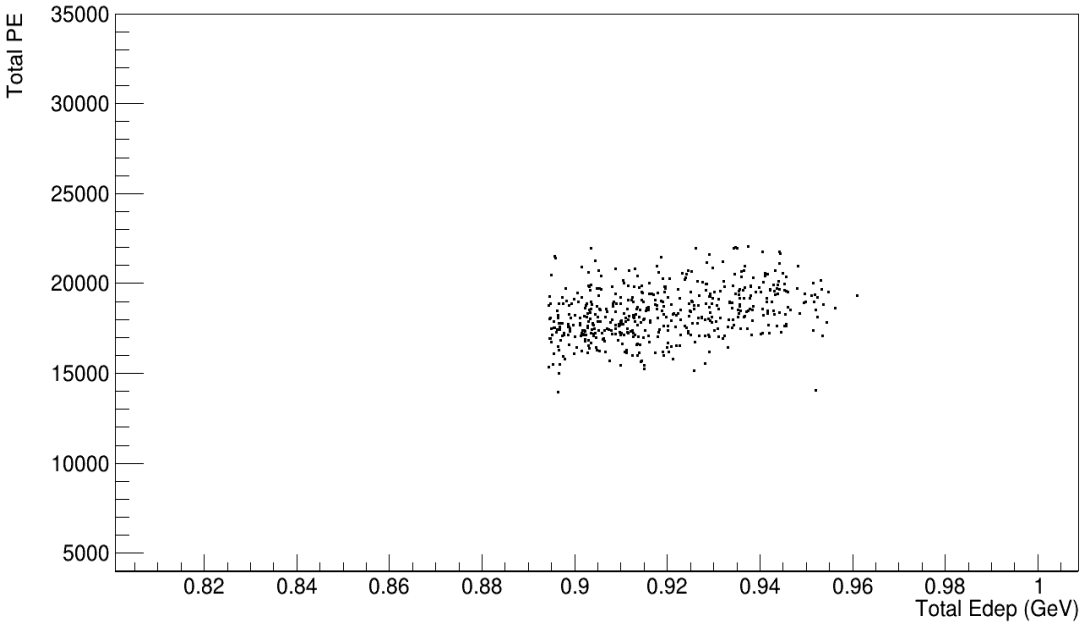


Number of flashes

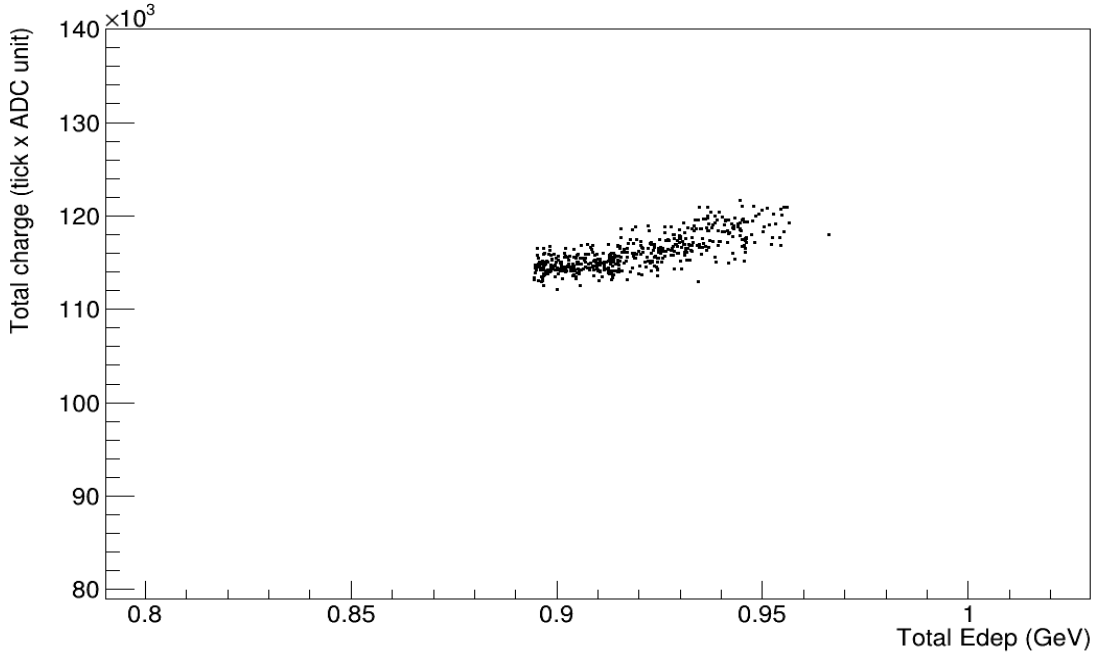


1 GeV Muons

- **LIGHT**:
  Photoelectrons vs Deposited Energy



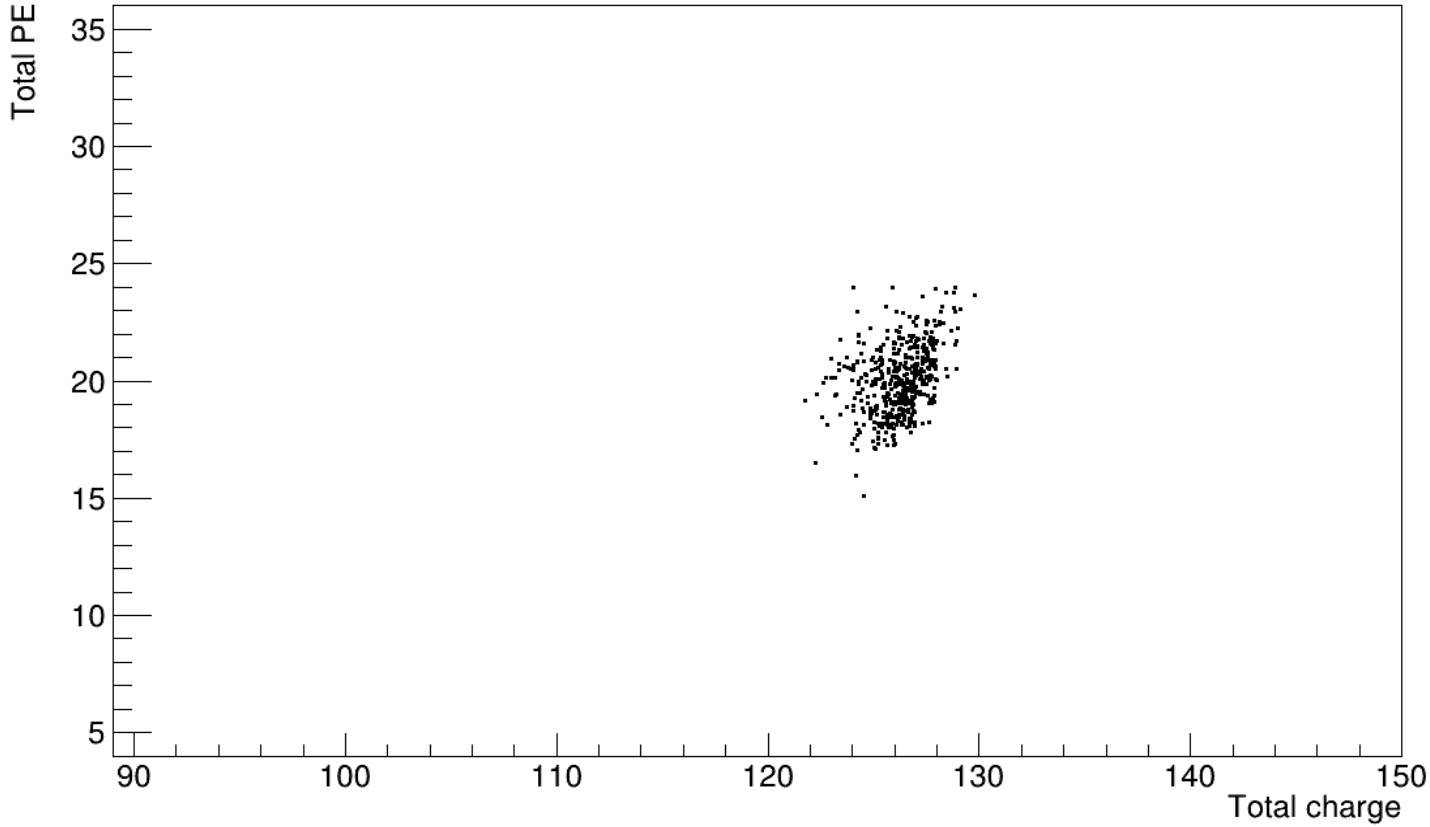
- **CHARGE**:
  Total Charge vs Deposited Energy



1 GeV Muons

- **LIGHT VS CHARGE per Deposited Energy**

Total charge vs Photoelectrons (deposited energy normalized)

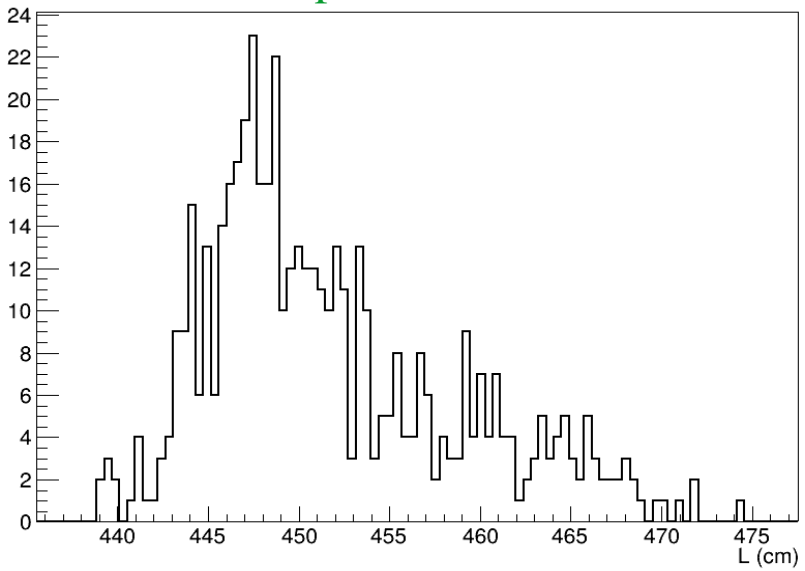


Correlation?

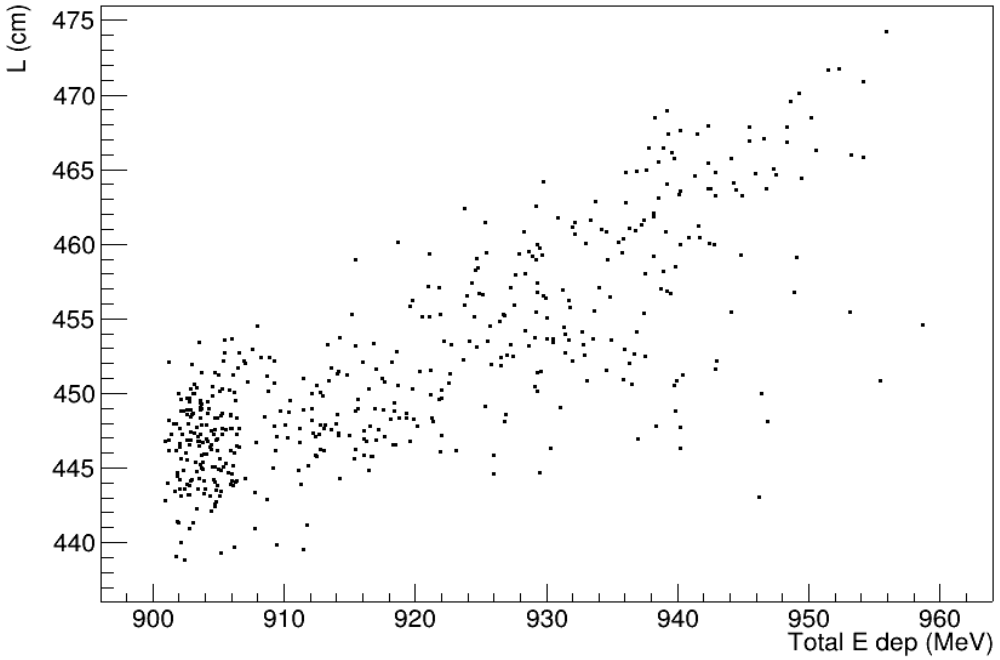
1 GeV Muons

- As for electrons, we checked in **IonAndScint**: Deposited energy, step length, Ionization electrons and Scintillation Gammas emitted

Total Deposition Path L

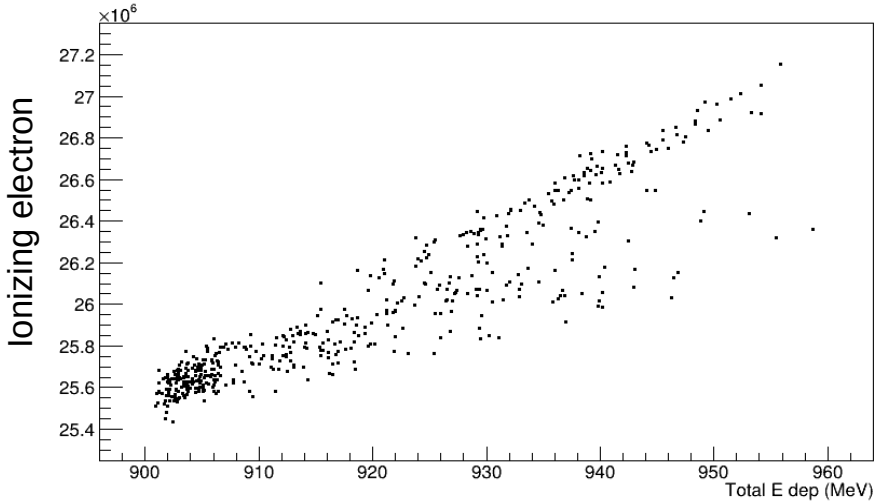


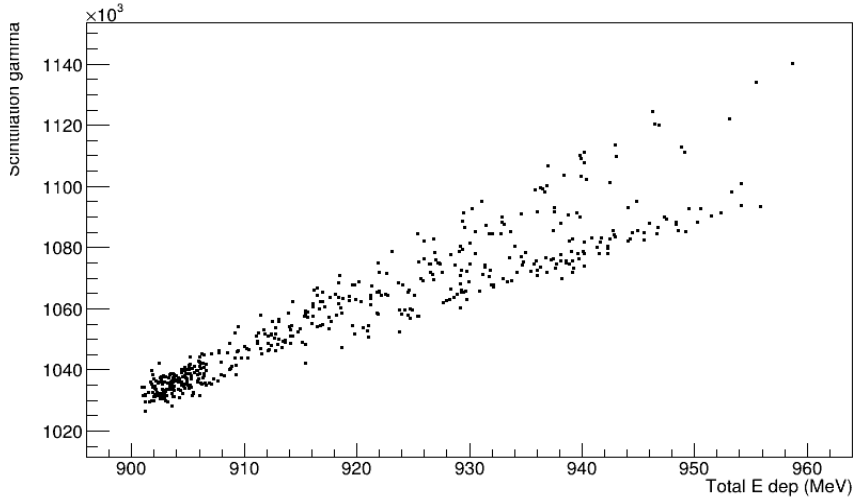
- Total Deposition Path L vs Total Deposited Energy :



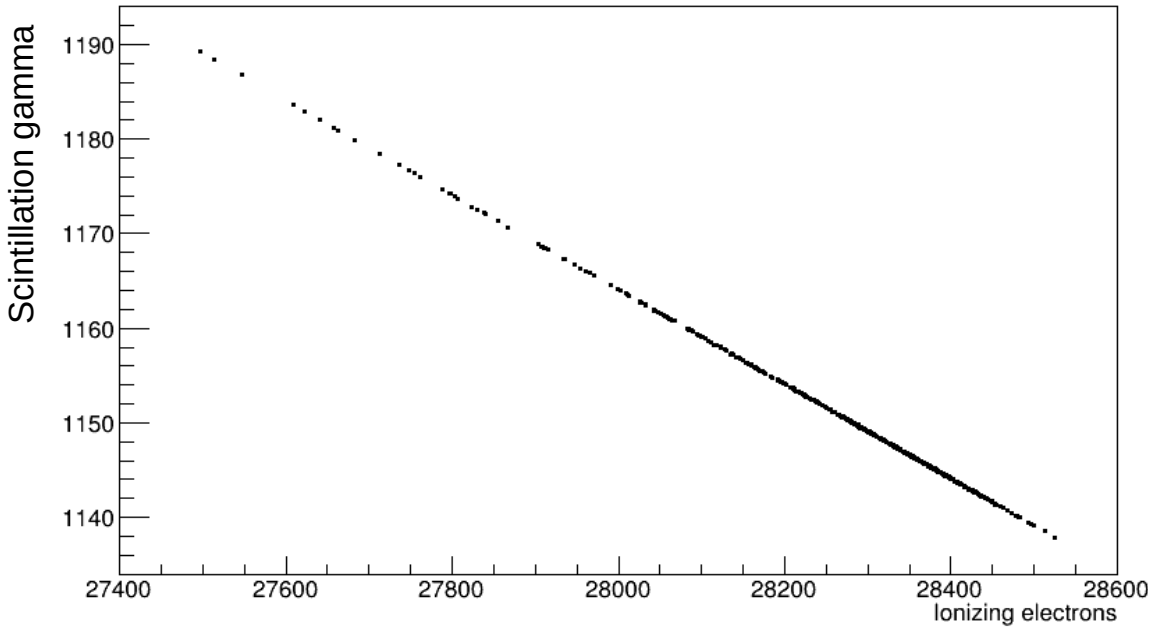
1 GeV Muons

- **IonAndScint**:
  Ionization electrons and Scintillation gammas emitted vs Deposited Energy





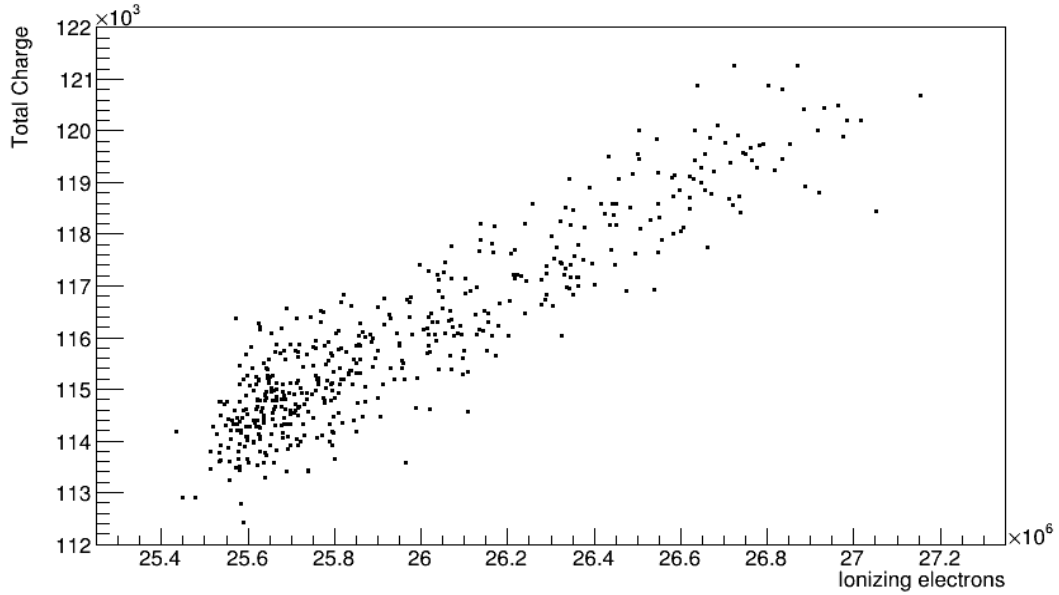
Scintillation Gammas vs Ionization Electron - Dep En Norm



1 GeV Muons

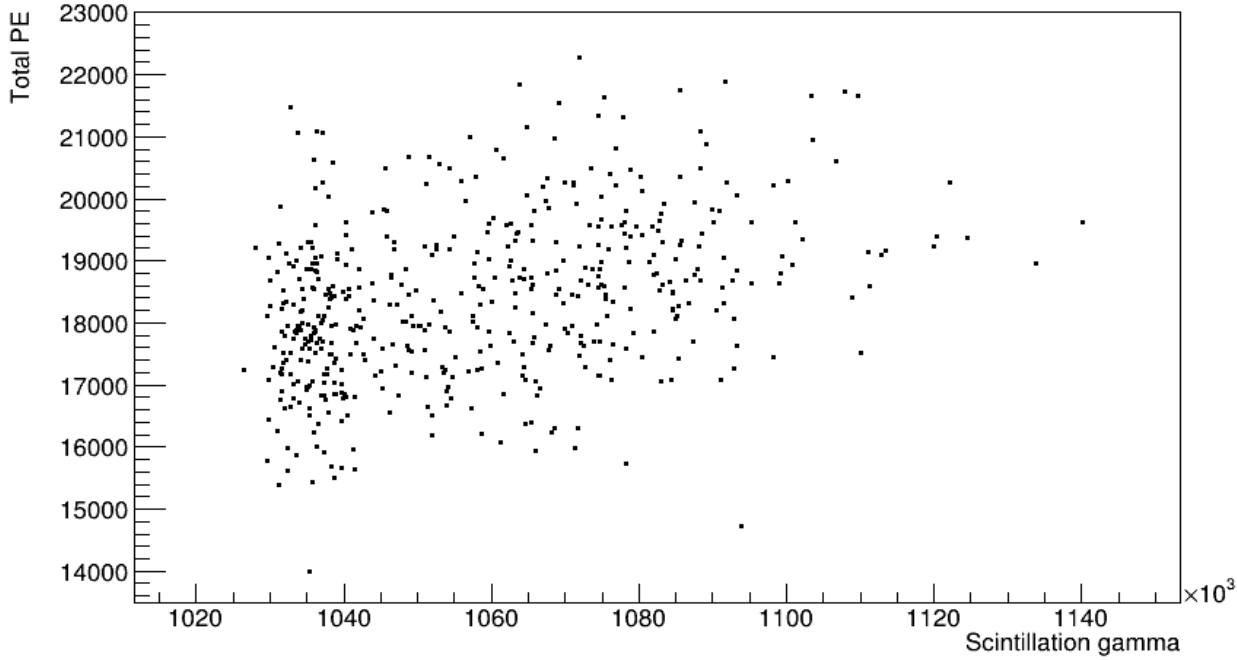
- Total Charge vs Ionization electrons

ok



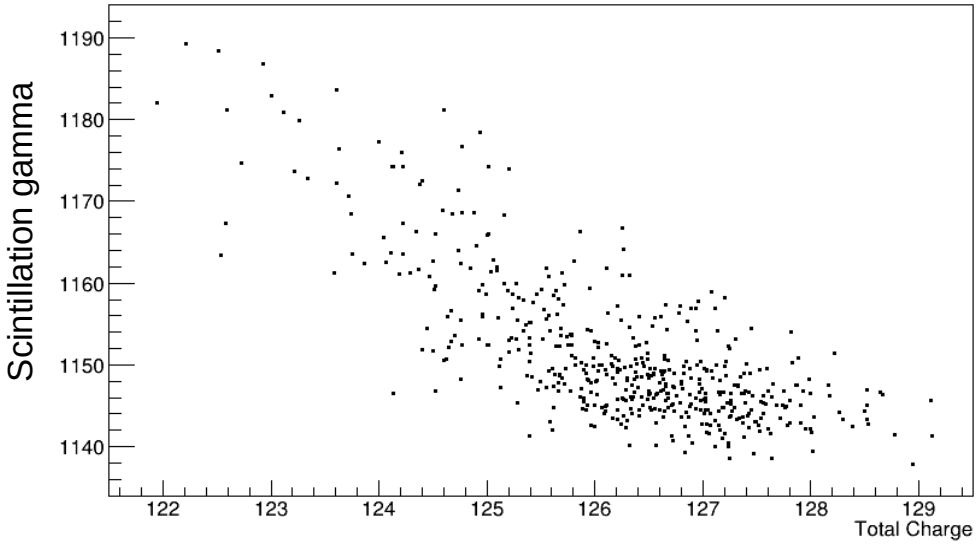
- Total PE from Flashes vs Scint. Gammas

Correlation?



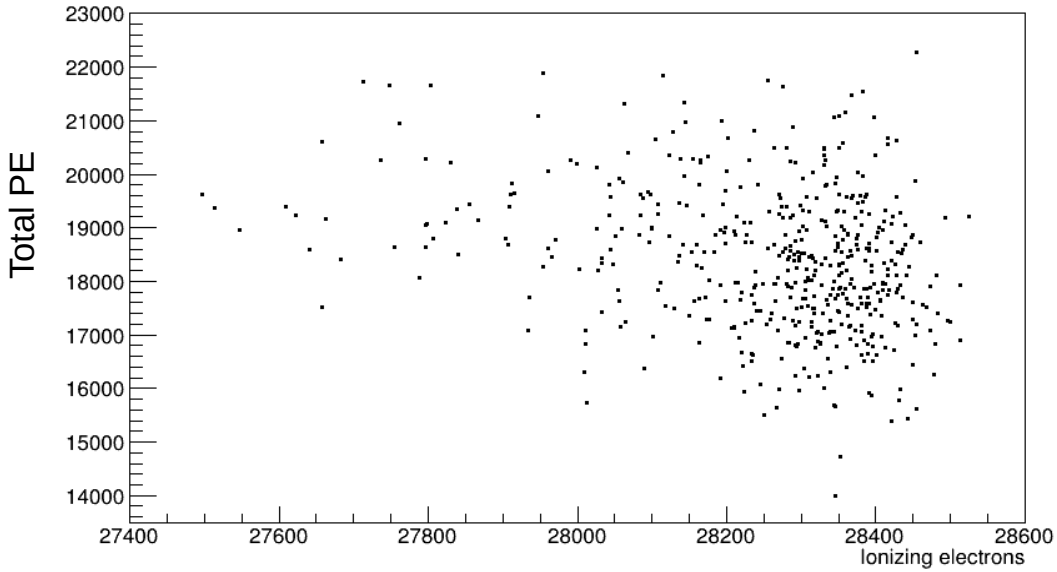
1 GeV Muons

Scintillation gammas vs Reco charge (deposited energy normalized)



Anticorrelated

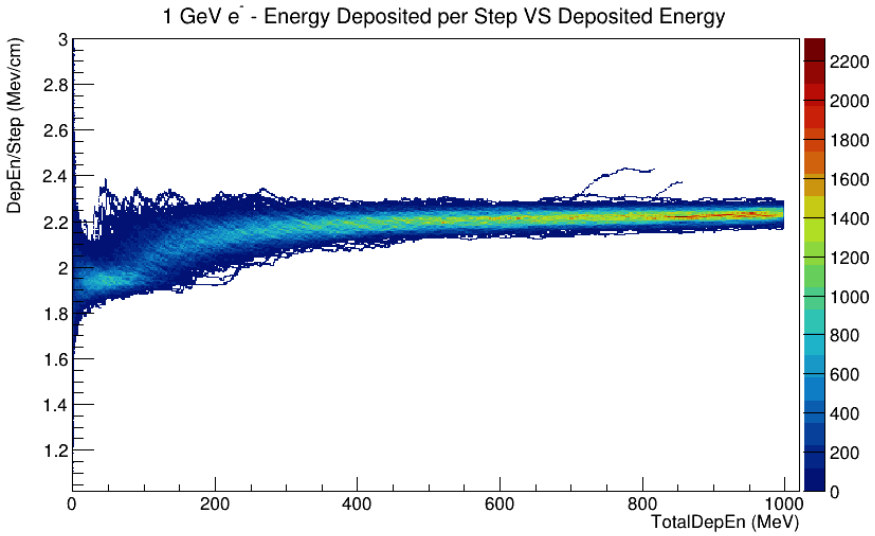
Flashes light vs Ionization electrons (deposited energy normalized)

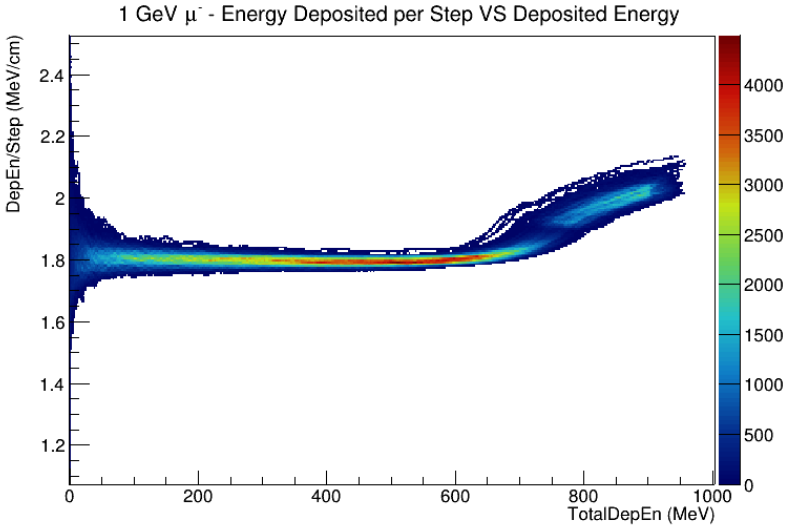


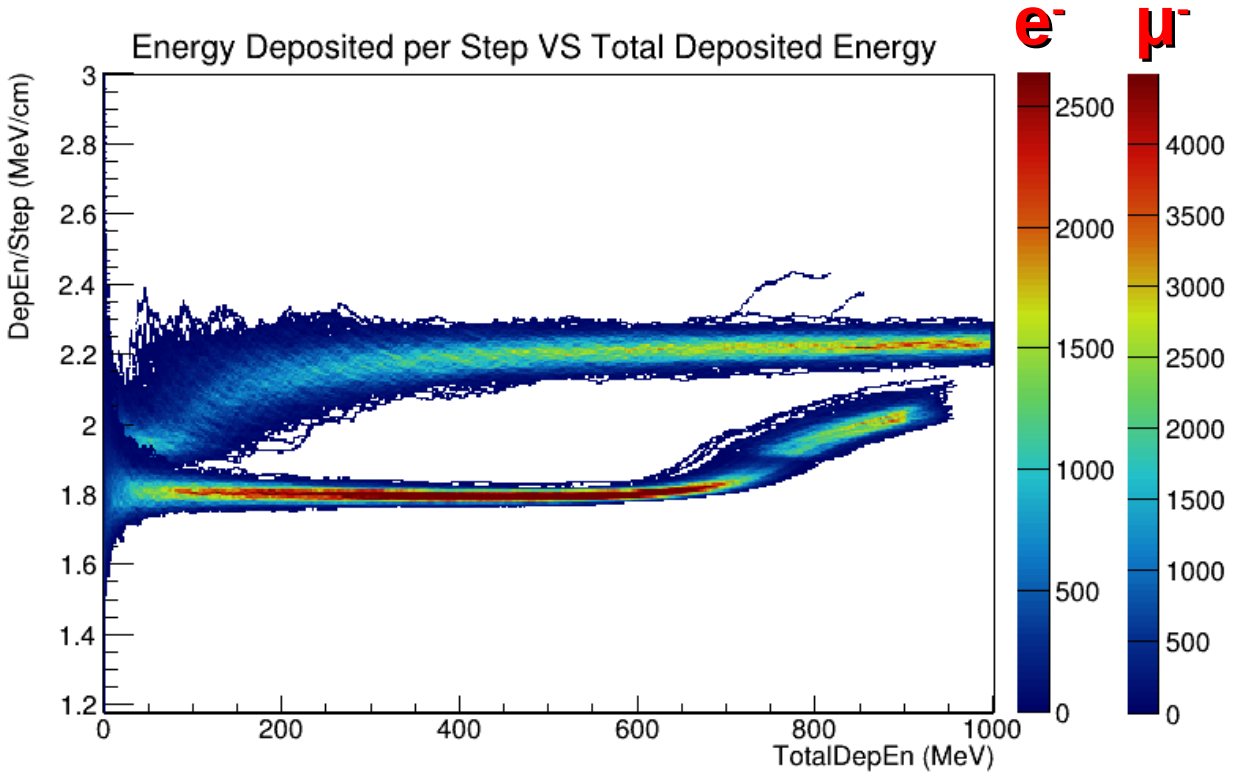
Correlation ?

1 GeV electrons and muons

Total Dep En per step vs Total deposited energy







Conclusions and Future plans

- The light/charge anticorrelation is not clearly visible in the simulated samples when using the PE information from the reconstructed flashes, could be due to the actual efficiency that we have with the optical detectors coverage of the FD (or maybe something to be improved in the reconstruction ?).

- We see a "quantized" deposited energy. It doesn't seem related to the reconstruction as we see it already at the IonAndScint level

- Keep investigating these features and start looking into a calorimetric measurement combining info from charge and light in FD.